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A Retrospective Review of Differences in Complication Rates between Dorsal Percutaneous and Mini-Open Surgical Fixation of Scaphoid Fractures

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Abstract

Objective We retrospectively reviewed the complications of 80 cases of scaphoid screw fixation in acute fractures and early nonunions comparing dorsal percutaneous and mini-open approaches.

Methods We performed a chart review of all patients who underwent surgical fixation of a scaphoid fracture or a nascent nonunion using a dorsal percutaneous or dorsal mini-open technique by a single surgeon. We collected data on patient demographics, including age and smoking status, time to surgery, fracture type, union, and the major and minor complications that occurred in each group. Fisher's exact tests were used to compare the complication rates between the groups.

Results We identified 80 patients who underwent surgical fixation. Of these, 44 underwent percutaneous fixation and 36 underwent mini-open fixation. All fractures went on to heal. There was a total of five complications identified. There were no major complications in the percutaneous group, but one major complication in the mini-open group (a delayed union that eventually healed at 6 months). There were two minor complications in each group. There was no statistically significant difference in total, major, or minor complication rates between the groups.

Conclusions This study suggests that a dorsal percutaneous surgical technique for scaphoid fracture repair does not affect the complication rate despite prior literature to the contrary. Both techniques analyzed produce excellent rates of union with very low complication rates. Surgeon-specific technique rather than operative approach or exposure may be responsible for previously reported complication rates in the fixation of scaphoid fractures.

Level of Evidence This is a level III, therapeutic study.

Keywords
- ► dorsal percutaneous approach
- ► scaphoid fracture
- ► scaphoid screw
- ► arthroscopy

Scaphoid fractures can lead to delayed union nonunion, and avascular necrosis, underlying the importance of optimal management.[1] At present, management of scaphoid fractures remains controversial, and treatment approach varies considerably between institutions and surgeons.[2,3] Proponents of both open and percutaneous surgery argue that operative fixation provides earlier return to work or sports than conservative management.[4,5]

Numerous studies have reported on the outcomes and complications related to various open and percutaneous techniques, but few studies have directly compared the complications of open versus percutaneous approaches. Complications

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related to the dorsal percutaneous approach were reported in detail by Bushnell et al in their review of 24 patients; they identified a 29% complication rate that is certainly worrisome.[6] Patients who may be interested in a less invasive approach are unlikely to select percutaneous surgery if this particular complication rate is disclosed to them. Despite this unacceptably high reported incidence of complications, many surgeons continue to perform percutaneous scaphoid fracture repairs and anecdotally report a much lower complication rate. Recent meta-analyses evaluating available studies have suggested better outcomes with open compared with percutaneous techniques; however, substantial limitations of the included studies raise doubt about the precision of their results.[2,7] More studies are needed to empirically demonstrate the superiority of one surgical approach over the other and to determine the critical factors producing good clinical outcomes in the management of scaphoid fractures.

In that context, the purpose of our study was to better understand complication rates of scaphoid screw fixation using a comparison group. Our goal was to retrospectively review and compare the complications of 80 cases of scaphoid screw fixation using a dorsal percutaneous versus a dorsal mini-open technique. Our hypothesis was that complication rates would not be significantly different between the two groups.

Materials and Methods

After obtaining Institutional Review Board (IRB) approval, we performed a retrospective review of all scaphoid fractures and nonunions that underwent operative fixation using either a dorsal percutaneous or mini-open approach between September 1, 2006 and December 1, 2018 by a single senior surgeon, whose level of expertise in scaphoid fracture repair is Level 5.

The inclusion criteria were as follows: surgical fixation of a scaphoid fracture or nascent nonunion (within 6 months of injury) using either a dorsal percutaneous or a dorsal mini-open technique, complete medical chart data availability of the analyzed variables, and a minimum follow-up period of 3 months along with presence of preoperative and postoperative imaging. Exclusion criteria included lack of available imaging and open treatment of transcaphoid perilunate fracture dislocations. Patients with other concomitant injuries were not excluded from our analysis.

There were no specific selection criteria for dorsal percutaneous versus dorsal mini-open technique. Patient, resident/fellow teaching experience, and operating room and facility related factors all played a role in the selection process.

Dorsal Percutaneous Technique

Under regional or general anesthesia, the extremity was exsanguinated and the tourniquet inflated. In 84% of our percutaneous patients, a diagnostic arthroscopy was performed first. If the arthroscopy was performed, the 3 to 4 portal incision was used for the percutaneous entrance; otherwise, a small 5 mm incision was made 1 cm distal and ulnar to Lister's tubercle (►**Fig. 1A**). The scaphoid fracture was reduced manually with manipulation of the distal pole, extending the distal pole of the fracture site with volar compression while flexing the wrist. If manual reduction maneuvers failed to reduce or maintain reduction of the scaphoid, Kirschner wire (K-wire) joysticks were placed in the proximal and distal poles of the scaphoid to manipulate the fracture fragments. Once the reduction was confirmed with fluoroscopy, a guidewire was placed through the percutaneous incision. The wrist was flexed, the guidewire was aimed along the longitudinal axis of the thumb, and then placed longitudinally through the central axis of the scaphoid. The guidewire position was confirmed with anteroposterior (AP), lateral, and oblique fluoroscopic imaging. The guidewire length was measured.

Scaphoid screw length was determined by subtracting 4 to 6 mm from the length of the central guidewire. If the fracture was believed to be rotationally unstable, a second derotational K-wire was placed percutaneously parallel to the initial guidewire with the removal of the derotational wire once the screw had been inserted. The central axis guidewire was then reamed by hand with the cannulated

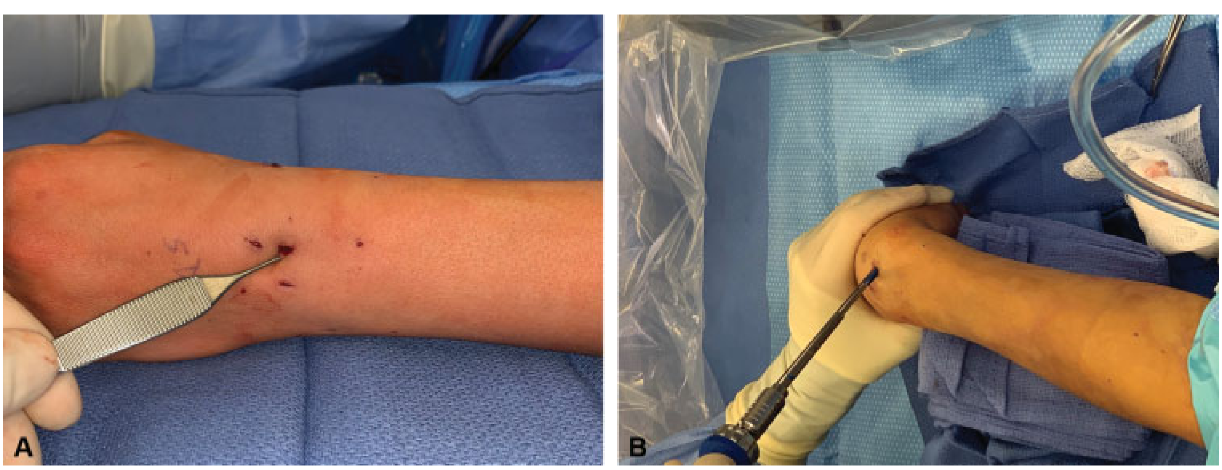

Fig. 1 (**A** and **B**) These images display arthroscopic, percutaneous scaphoid fracture repair. Image (**A**) shows the 3 to 4 arthroscopic portal that is used for screw insertion, but also the 4–5 arthroscopic portal. In this case, midcarpal arthroscopy was also performed through the 3 to 4 midcarpal portal to assess scapholunate ligament integrity. Image (**B**) depicts screw percutaneous screw insertion under fluoroscopic guidance.

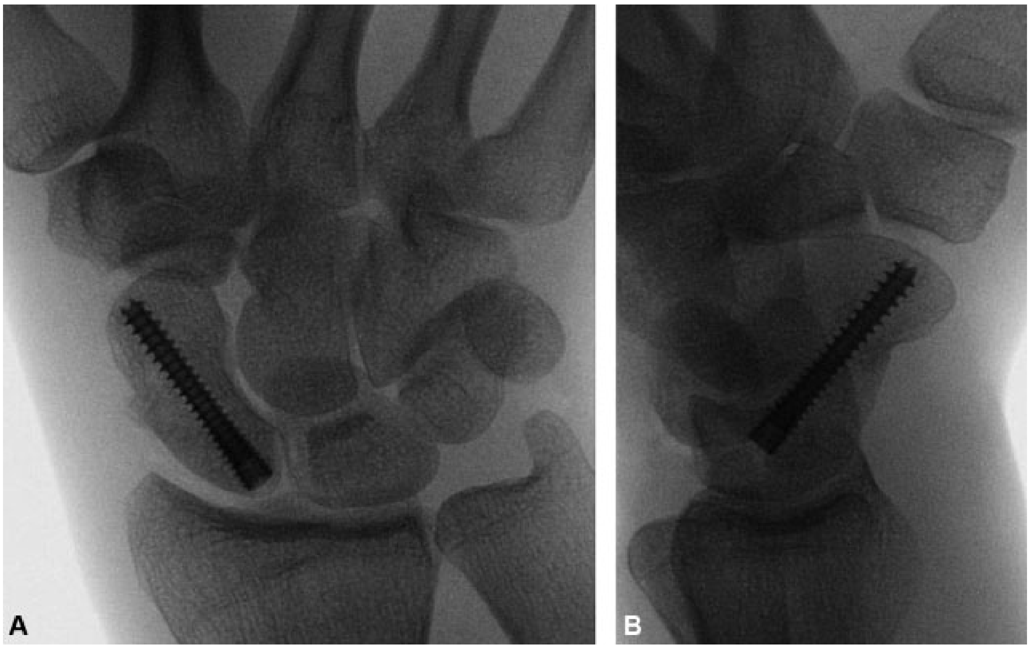

Fig. 2 (**A** and **B**) Fluoroscopic images of the percutaneously placed scaphoid screw after guidewire removal, (**A**) anteroposterior scaphoid, and (**B**) lateral of the scaphoid.

drill. The screw was placed (►**Fig. 1B**) in standard fashion and the K-wires were removed. Fluoroscopy was then used to confirm screw position and reduction in the fracture in AP, lateral, and oblique views (►**Fig. 2A** and **B**). The wrist was taken through a passive range of motion to assess the integrity of the finger and thumb extensors by observing finger motion with wrist tenodesis. A single suture was placed to close the percutaneous incision. After sterile dressings, the wrist was placed in a volar wrist splint.

Dorsal Mini-Open Technique

A small, 1.5 to 2 cm, longitudinal incision (►**Fig. 3A**) just ulnar and distal to Lister's tubercle was made. Blunt dissection was carried down to the distal dorsal retinaculum of the wrist. The tendons of the fourth and third compartments were visualized and the extensor digitorum communis was retracted ulnarly and the extensor pollicis longus was retracted radially without fully liberating them from their compartments (►**Fig. 3B**). Dissection proceeded just distal to the dorsal rim of the distal radius, which is just distal to the extensor retinaculum of the dorsal compartments of the wrist. A small longitudinal capsulotomy was made and the scapholunate ligament and proximal pole of the scaphoid were visualized. The scaphoid fracture was then reduced manually or with joysticks as with the percutaneous approach. The guidewire was visually placed at the proximal central ulnar border of the scaphoid and advanced with the wrist in flexion. The operation then proceeded just as with the percutaneous approach. After insertion, the position of the screw and reduction was confirmed with fluoroscopy as above. The proximal screw position was visualized to ensure it

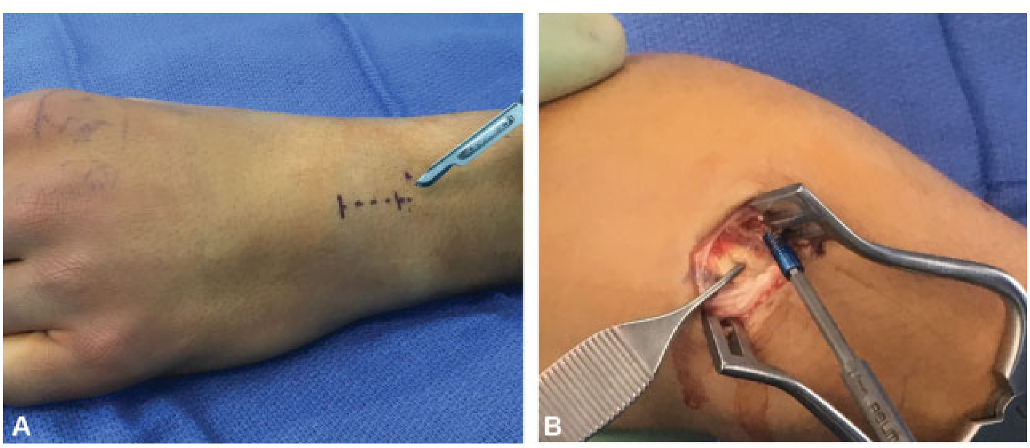

Fig. 3 (**A** and **B**) These clinical photographs reveal the mini-open approach utilized in this study. Photograph (**A**) shows the incision site for the mini-open approach to scaphoid fracture repair. The isolated dot just above the 15 blade localizes Lister's tubercle. Photograph (**B**) demonstrates insertion of the scaphoid screw, just ulnar to the extensor tendons of the fourth dorsal compartment and just radial to the extensor pollicis longus (retracted). This interval is just distal to the articular surface of the dorsal rim of the distal radius.

was not extending beyond the edge of the cartilage. After irrigation of the wound, the dorsal capsule was closed, the extensor tendons returned to their resting position, and the skin was closed with standard technique, followed by dressings and a volar wrist splint.

Patients were followed in an outpatient clinic with consecutive radiographs until they were deemed to be clinically and radiographically healed by the operating surgeon. Complications were identified through a detailed analysis of the medical record of each patient, including operative reports and follow-up notes. Major complications included any complication necessitating additional surgical intervention, intraoperative fracture, delayed union, nonunion, malunion, compartment syndrome, permanent nerve injury, vascular injury, tendon or muscle rupture, complex regional pain syndrome, septic arthritis, permanent significant loss of wrist function, and permanent stiffness. Minor complications included breakage of surgical instruments causing no harm to the patient, complications requiring additional nonsurgical intervention or prolongation of or deviation from the standard surgical technique, superficial infections, temporary neurologic symptoms, transient hand or wrist stiffness, and transient loss of wrist function. Fisher's exact tests were used to analyze complication rates with a *p*-value of <0.05 being considered statistically significant.

Results

Eighty patients met our inclusion criteria, of which all were analyzed. The mean follow-up time was 6.3 months. Forty-four patients underwent percutaneous fixation and 36 patients underwent mini-open fixation. All fractures healed and achieved union, although there was a single case of a delayed union that eventually healed in 6 months in the mini-open group. The total complication rate in all groups was 6.25%. Our statistical analysis demonstrated no significant difference in total, major or minor complication rates between groups: the *p*-value for total complications between the two groups was $p = 0.65$, major complications was $p = 0.45$, and minor complications was $p = 1.0$. None of these *p*-values were significant. A breakdown of the patient characteristics of both groups is given in ►**Table 1**.

Table 1 Characteristics of patients

	Percutaneous	Mini-open	All patients
Mean age (± SD)	23.8 (± 9.8)	29.9 (± 16.1)	26.6 (± 13.3)
Male/female	38 / 6	33 / 3	71 / 9
Mean days to surgery (± SD)	36 (± 57.3)	44.9 (± 105.2)	40.3 (± 83.2)
Percent smokers	14.3%	25%	19.1%
Acute/delayed treatment	38 / 6	31 / 5	69 / 11

Abbreviation: SD, standard deviation.

Major Complications

There was one major complication in the mini-open group (2.78%), and no major complications in the percutaneous group (0%). The rate of major complications in all groups was 1.25%, and there was no statistically significant difference in major complications between the two groups. The major complication was a delayed union that occurred in a 32-year-old man, who was a smoker. Despite radiologic evidence of healing including bridging bone on computed tomography (CT) (appropriate evidence of radiographic healing), the patient continued to have pain for 6 months (delayed evidence of clinical healing). His pain resolved after 6 months without any additional intervention, indicating final clinical healing.

Minor Complications

There were two minor complications in the percutaneous group (5%) and two in the mini-open group (5.56%). There was no statistically significant difference in minor complication rates between the two groups. In each group, one minor complication occurred in the operative period and one occurred in the postoperative period. In the percutaneous group, there was an intraoperative pin breakage and one case of transient radial sensory nerve sensitivity. In the mini-open group, there was a case of an intraoperative pin breakage and one case of a painful hypertrophic scar. Both cases of guidewire breakage required ∼10 minutes for wire removal, causing a minor deviation from surgical technique, specifically a small percutaneous incision at the volar radial thumb base to remove the broken end of the guidewire.

Discussion

Since Dr. Joseph Slade popularized the dorsal percutaneous approach to scaphoid fracture repair, surgeons have been more routinely accessing the dorsal aspect of the scaphoid for surgical screw fixation as an alternative to the open volar approach.[8–14] In our study, we aimed to detail the complications and union rates of dorsal percutaneous and mini-open approaches and to determine whether there was a difference in complication rates between the two groups.

Complications related to the dorsal percutaneous approach were reported to be 29% by Bushnell et al in their review of 24 patients.[6] We believe a 29% complication rate (even if minor complications are included) is an unacceptably high rate for patients to comprehend when considering percutaneous surgery to repair their scaphoid fractures. Patients are unlikely to select this type of surgery if such a complication rate is disclosed to them. Anecdotally, the authors have witnessed and heard accounts from other surgeons of substantially fewer complications. We elected to study this critical issue to provide patients with more accurate reporting of complications.

We found a 4.5% complication rate in our percutaneous group and an 8.3% rate in our mini-open group. These are substantially lower than the 29% complication rate Bushnell et al reported using their dorsal percutaneous approach. Notably, in our percutaneous group of 44 patients, we had a total of two complications (both minor), compared with the seven complications (5 major and 2 minor) in their 24 patients.

A review of their complications reveals several cases involving problems with screw placement, including a case of errant screw placement with inadequate capturing of the distal fragment, an excessively long screw that caused irritation, a delayed union that caused the screw to settle and cause pain, and a postoperative proximal pole fracture in a patient with a short screw that possibly created a stress riser. These cases highlight the importance of accurate screw length and correct central placement, two facts that are directly controlled by the hand of the surgeon. Comparatively, the two complications observed in our 44 percutaneously treated patients were minor, and ultimately led to no clinical or functional issues. We believe it is likely that the complications reported by Bushnell et al may have occurred during a "learning phase" period regarding the percutaneous approach. Certainly, their reporting does raise concerns that adequate education, training, and technical skills are important before trying any new technique.

Comparatively, we identified one major and two minor complications in our mini-open group of 36 patients. The major complication involved a painful, clinically delayed union in a smoker, despite the presence of 50% bridging bone on CT. It took over 6 months for this patient to show signs of clinical healing. Given the lack of intraoperative complications and the radiographic evidence of healing, it is unclear if a change in management would have led to less pain. However, one could theorize that with a smaller operative dissection, postoperative pain may improve more quickly. The minor complications in the mini-open group involved an intra-operative pin breakage and a case of a painful hypertrophic scar. It is possible that the hypertrophic scar could have been avoided with a percutaneous approach. Otherwise, regardless of operative approach or exposure, it appears that achieving precise fracture reduction and screw fixation led to high union and low complication rates in both of our groups, with no statistically significant difference between the percutaneous and mini-open techniques in total, major, and minor complication rates or union rates.

Low complication rates and high rates of union with open and percutaneous fixation of the scaphoid have been documented in numerous studies.[2,4,5,7] When compared with percutaneous techniques, open fixation provides the benefit of better visualization of the starting point of the central axis guidewire.[15] This visual advantage does allow some surgeons to be more accurate with guidewire and screw placement. It is intuitive that even mini-open techniques require additional capsular and soft tissue dissection and risk violating the already tenuous scaphoid blood supply.[16] Percutaneous techniques limit soft tissue dissection, theoretically mitigating these risks, but may increase articular punctures attempting to place a central guide wire.

Mini-open techniques have been described as an alternative to percutaneous techniques given that they limit soft tissue dissection while providing better visualization of the guidewire starting position.[9,17–19] However, seldom have these techniques been directly compared with each other; rather, most studies compare nonoperative management to either an open or percutaneous approach. Recently, some authors have tried to compare open and percutaneous techniques by analyzing the available literature. For example, in a meta-analysis, Alshryda et al found that trials that compared open fixation to nonoperative management for acute scaphoid fractures had a higher union rate with the operative technique, while there was no significant difference in union rates in trials that compared percutaneous fixation to nonoperative management.[7] Ibrahim et al and Li et al found similar results in their meta-analyses, suggesting better outcomes with open fixation versus nonsurgical management, while there was no significant difference in union rates with percutaneous versus nonsurgical management.[4,5] Overall, these studies suggest that the assumption that open techniques are superior to percutaneous approaches is not empirical and requires more investigation.

We were unable to identify another study directly comparing complication rates of dorsal percutaneous and mini-open approaches in the fixation of scaphoid fractures as ours does. A better understanding of actual complication rates is especially important when counseling our patients and when considering these described meta-analyses that have raised doubt about the superiority of one approach over the other.[4,5,7]

Our mini-open and percutaneous techniques are similar to perform, with both techniques having the same goals for reduction, guidewire placement, and screw placement. The main difference involves the ease offered by the mini-open approach in visualizing the guidewire starting point, allowing for more optimal screw placement down the central axis of the scaphoid. A percutaneous approach, on the other hand, offers the advantage of a smaller incision and less capsular dissection. We believe that either technique, mini-open or percutaneous screw placement, can offer excellent results assuming the basic tenets of scaphoid reduction, implant selection, and ideal scaphoid screw placement are maintained. Additionally, technical issues and difficulty with using either technique can be minimized with adequate training.

We recognize the limitations of our retrospective, single-surgeon study. Our study was not randomized, had no functional outcomes, and had no long-term follow-up. For example, we have not studied the impact of approach on posttraumatic arthritis that may form after antegrade scaphoid screw fixation. Our choice of technique was dictated by such factors as resident teaching experience and operative equipment availability. In addition, time to surgical fixation was variable given that this study was comprised of all scaphoid fractures, including select nascent nonunions that were appropriate for screw fixation without bone grafting. Moreover, we had a heterogeneous patient population, with some patients suffering concomitant hand and wrist injuries as well as lower extremity or other multitraumas. We did not classify fracture patterns in the two groups and one group may have had more displaced fractures than the other group. Our intent was not to compare function outcomes of specific scaphoid fracture types but rather to understand the differences in complications using two different techniques. Certainly, another limitation to our study was the use of plain radiographs to evaluate bone healing rather than CT scans in all patients.

Lastly, we did not assess time to union. The authors believe this particular time point is somewhat arbitrary throughout the literature as there is still disagreement as to what characterizes a definitively healed scaphoid. In addition, it is impossible to say the fracture was healed on a specific clinic date (we don't obtain weekly CT scans, rather every 3 months when union is in question or return to sport/activity is desired). As a result, this specific marker, time to union, is inherently flawed. Still, we understand that many surgeons would like to know if surgical approach to the scaphoid affects healing time. We are unable to answer this specific question.

In conclusion, we identified no significant difference in complication rate between a mini-open and dorsal percutaneous approach in the treatment of a diverse group of scaphoid fractures. There is considerable variability in the management of scaphoid fractures and a shortage of high-quality studies from which we can derive concrete, evidenced-based management algorithms. In our study, it appears that the dorsal approach used, percutaneous versus open-mini, may not be as important to surgical outcomes as adhering to precise fracture reduction and fixation techniques. In fact, surgeon-specific technique rather than fracture type, operative approach, or exposure may be responsible for complication rates in the fixation of scaphoid fractures.

Conflict of Interest
None declared.

References

1 Steinmann SP, Adams JE. Scaphoid fractures and nonunions: diagnosis and treatment. J Orthop Sci 2006;11(04):424–431
2 Alnaeem H, Aldekhayel S, Kanevsky J, Neel OF. A systematic review and meta-analysis examining the differences between nonsurgical management and percutaneous fixation of minimally and nondisplaced scaphoid fractures. J Hand Surg Am 2016;41 (12):1135–1144.e1
3 Pinder RM, Brkljac M, Rix L, Muir L, Brewster M. Treatment of scaphoid nonunion: a systematic review of the existing evidence. J Hand Surg Am 2015;40(09):1797–1805.e3
4 Ibrahim T, Qureshi A, Sutton AJ, Dias JJ. Surgical versus nonsurgical treatment of acute minimally displaced and undisplaced scaphoid waist fractures: pairwise and network meta-analyses of randomized controlled trials. J Hand Surg Am 2011;36(11):1759–1768.e1
5 Li H, Guo W, Guo S, Zhao S, Li R. Surgical versus nonsurgical treatment for scaphoid waist fracture with slight or no displacement: a meta-analysis and systematic review. Medicine (Baltimore) 2018;97(48):e13266
6 Bushnell BD, McWilliams AD, Messer TM. Complications in dorsal percutaneous cannulated screw fixation of nondisplaced scaphoid waist fractures. J Hand Surg Am 2007;32(06):827–833
7 Alshryda S, Shah A, Odak S, Al-Shryda J, Ilango B, Murali SR. Acute fractures of the scaphoid bone: systematic review and meta-analysis. Surgeon 2012;10(04):218–229
8 Adamany DC, Mikola EA, Fraser BJ. Percutaneous fixation of the scaphoid through a dorsal approach: an anatomic study. J Hand Surg Am 2008;33(03):327–331
9 Bedi A, Jebson PJ, Hayden RJ, Jacobson JA, Martus JE. Internal fixation of acute, nondisplaced scaphoid waist fractures via a limited dorsal approach: an assessment of radiographic and functional outcomes. J Hand Surg Am 2007;32(03):326–333
10 Drac P, Cizmar I, Manak P, et al. Comparison of the results and complications of palmar and dorsal miniinvasive approaches in the surgery of scaphoid fractures. A prospective randomized study. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub 2014;158(02):277–281
11 Gürbüz Y, Kayalar M, Bal E, Toros T, Küçük L, Sügün TS. Comparison of dorsal and volar percutaneous screw fixation methods in acute type B scaphoid fractures. Acta Orthop Traumatol Turc 2012;46(05):339–345
12 Jeon IH, Micic ID, Oh CW, Park BC, Kim PT. Percutaneous screw fixation for scaphoid fracture: a comparison between the dorsal and the volar approaches. J Hand Surg Am 2009;34(02): 228–36.e1
13 Slade JF III, Grauer JN, Mahoney JD. Arthroscopic reduction and percutaneous fixation of scaphoid fractures with a novel dorsal technique. Orthop Clin North Am 2001;32(02):247–261
14 Slade JF III, Gutow AP, Geissler WB. Percutaneous internal fixation of scaphoid fractures via an arthroscopically assisted dorsal approach. J Bone Joint Surg Am 2002;84-A(Suppl 2):21–36
15 DeGeorge BR Jr, Shin AY. Volar approach to percutaneous fixation of acute nondisplaced fractures of the scaphoid. Tech Hand Up Extrem Surg 2019;23(01):6–9
16 Evans S, Brantley J, Brady C, Salas C, Mercer D. Structures at risk during volar percutaneous fixation of scaphoid fractures: a Cadaver study. Iowa Orthop J 2015;35:119–123
17 Geissler WB, Adams JE, Bindra RR, Lanzinger WD, Slutsky DJ. Scaphoid fractures: what's hot, what's not. J Bone Joint Surg Am 2012;94(02):169–181
18 Inoue G, Shionoya K. Herbert screw fixation by limited access for acute fractures of the scaphoid. J Bone Joint Surg Br 1997;79(03): 418–421
19 Yassaee F, Yang SS. Mini-incision fixation of nondisplaced scaphoid fracture nonunions. J Hand Surg Am 2008;33(07):1116–1120